George Washington
Birthplace National
Monument

presents…

HOW MATH & SCIENCE CHANGED GEORGE WASHINGTON'S LIFE

Student Workbook

Table of Contents

Helpful hints for visiting the park:

- Wear comfortable walking shoes

- Wear appropriate clothing for being outside

- Complete the pre-visit exercises in math and science

Acknowledgements

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United States Department of the Interior

NATIONAL PARK SERVICE
George Washington Birthplace National Monument
and
Thomas Stone National Historic Site
1732 Popes Creek Road
Washington's Birthplace, Virginia 22443

Dear Students,

Thank you for participating in "How Math and Science Changed George Washington's Life." This program is the creation of George Washington Birthplace National Monument with Richmond County Public Schools. This program has been awarded grants through the National Park Foundation with funding provided by the Exxon Corporation and the "Parks As Classrooms®" grant from the National Park Service.

"How Math and Science Changed George Washington's Life" has you calculating the same types of math problems that George Washington did when he was your age. You will learn the basics of surveying (measuring land) used by young George Washington. You will also learn to read the landscape on your visit to George Washington Birthplace National Monument. The lessons in this workbook will help you understand the math concepts and the importance of the natural landscape, which will prepare you to walk in George Washington's shoes during your visit to the park.

This workbook will help you gain knowledge in math and science. The visit to George Washington Birthplace National Monument will provide insight into Washington the man as you apply classroom lessons to the real world.

John J. Donahue
Superintendent

Background Information

Is your mother or father keeping something valuable for you until you are older? Maybe it is your grandfather's pocket watch that he wanted you to have. It could be your grandmother's photograph. Your family keeps this item safe until you can understand its importance for you and your family. These items tell a story about your family and your heritage. You will want to keep these "special" family items to pass down to your children.

The National Park Service has the same role your parents do in keeping your "special" family items safe. The National Park Service protects places that have a story to tell about the landscape, wildlife, or history. These sites are protected because they are "special places" for the people of the United States. The role of the National Park Service has been to protect and preserve (keep safe) these places for future generations.

Where George Washington was born is a "special place" for the people of the United States. The birthplace is important because George Washington was the "Father of Our Country." Visitors have traveled to the birthplace of George Washington since 1815. George Washington Birthplace National Monument became a part of the National Park System in 1930. Across the United States, 378 places that tell a story are being kept safe by the National Park Service. These National Parks belong to you. This means that your children and your children's children will be able to visit these sites just as you can.

George Washington

Any textbook in the world that includes United States history must mention George Washington. He was Commander-in-Chief of the Continental Army, President of the Constitutional Convention, and the first President of the United States. George Washington was the one man who would defeat the greatest military power on earth, unite thirteen diverse colonies into the first successful republic since Rome, and lend his character to the newly created office of President.

The celebration of Washington's contributions to the United States has overshadowed his early years. The humble beginnings of George Washington influenced his character and ambition as he strove to distinguish himself in Colonial Virginia society. The profession that began Washington's climb to fame was that of land surveyor.

George Washington was born February 22, 1732, to Augustine and Mary Ball Washington at Popes Creek Plantation in Westmoreland County, Virginia. Augustine and Mary Ball had five children after George: Elizabeth, Samuel, John Augustine, Charles, and Mildred. In 1735 the Washington family moved from Popes Creek to Little Hunting Creek. They lived there until moving to Ferry Farm on the Rappahannock River in 1738.
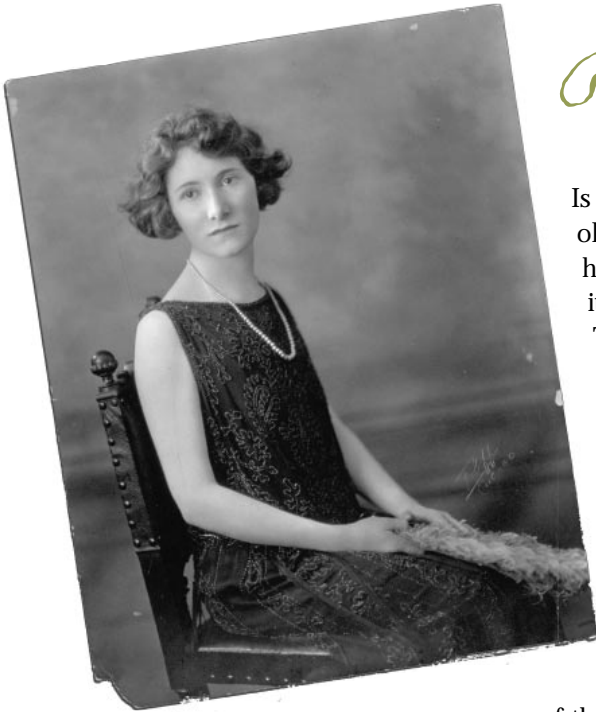
When George was 11 years old, his father, Augustine, died. George inherited Ferry Farm where he lived with his mother and siblings. This modest plantation could not maintain his lifestyle in the Virginia gentry. Mary Ball Washington could not afford to send George to England for an education. At the age of thirteen, George Washington began studying geometry and using a set of surveying instruments from the storehouse at Ferry Farm. Surveying was an educated profession of considerable importance that provided a substantial income.

Between the Rappahannock and Potomac Rivers lies the Northern Neck of Virginia. Lord Fairfax received this land as a gift from the King of England. Colonists seeking land in the Northern Neck applied to Lord Fairfax for permission to settle and were given a survey warrant for a set amount of acres in a specific location. Lord Fairfax was the richest man in the colony and owned over five million acres.

Young George Washington met and impressed Lord Fairfax. Fairfax sent Washington on his first surveying expedition at the age of 16. One year later, George was appointed surveyor for Culpeper County in the Northern Neck. He had a profitable surveying career and established a reputation of fairness, honesty, and dependability. It was during this time that Washington began to buy and speculate in land, a habit he would continue throughout his life. George Washington became an expert at identifying trees as markers for surveys and at recognizing important features of the natural landscape. When George was 18 years of age, he bought 1459 acres of land in Frederick County (Winchester, Virginia). Eight years later, he would be elected to the

Surveying in Colonial Virginia

"English colonists who ventured across the Atlantic to settle in the forested wilds of Virginia well understood the unique importance of the surveyor in their society. Land was the lure that led soldiers and gentlemen to risk the treacherous voyage. The hope of land induced many poorer English men and women to indenture themselves to labor in colonial fields to pay their passage. Mile upon mile stretched backward from the James, York, Rappahannock, and Potomac Rivers without the stone markers or hedges which delineated fields of landlords and tenants on the British Isles. Immigrant colonists gazing at a wilderness envisaged its taming and imagined new markers bounding the edges of their own fields and meadows. The men who could measure the metes and bounds of those fields held the key to transforming a worthless uncultivated territory into individual farms. Until the cadastral surveyor's chain traversed the land, it could not be converted to private property and personal advantage."[1]

Owning land in England was impossible for most people but in Virginia land was plentiful. Starting in 1607, Englishmen came to Jamestown with the dream of owning their own land. There were many ways a new settler could obtain land. The most popular method was called indentured servitude, which required poor Englishmen to work for a period of four to seven years to pay for their passage to Virginia. When the servant had worked out his time, the servant received 50 acres of land, as did the planter.

The land had to be surveyed or measured in order to provide an official record where the land was located and to make sure the landowner received the correct number of acres. Since the main reason for owning land in Virginia was growing tobacco, the landowner wanted the best farmland included in his survey. The surveyor would adjust the perimeter (boundaries) of the survey to include the best farmlands. The result would be irregular shaped surveys.

Each land survey was measured in acres. An acre was the amount of land a yoke of oxen could plow in a day.[2] This term has been used for land measurement since medieval times.[3] The standard measurement for surveying was a pole, which was 16.5 feet. It took 160 square poles to equal one acre. In 1620, Edmund Gunter introduced an improved chain of 66 feet that made the calculation of an acre easier.[4] The Gunters Chain was equal to four poles in length, and ten square Gunters Chains are equal to one acre. Surveyors carried a Gunters Chain, a surveying compass, and a notebook to record their observations and measurements.

[1] Hughes, Sarah S., *Surveyors and Statesmen: Land Measuring in Colonial Virginia*, p. 1.

[2] Ibid, p.29.

[3] Ibid, p.29.

[4] Ibid, p.32.

House of Burgesses from Frederick County. This was the beginning of Washington's political career.

Surveying provided George Washington with a familiarity of the colony's back-country while he developed wilderness survival skills. An important part of military strategy in colonial times was the ability to use the natural features of the land to erect fortifications. Most officers were engineers in that they could use the landscape such as hills, rivers, and location to construct forts. All engineers were trained in surveying. The skills and education Washington obtained as a surveyor were useful when Governor Dinwiddie appointed him as major in the Virginia Militia. Washington was twenty years old at the time of the appointment; thus would begin his military career.
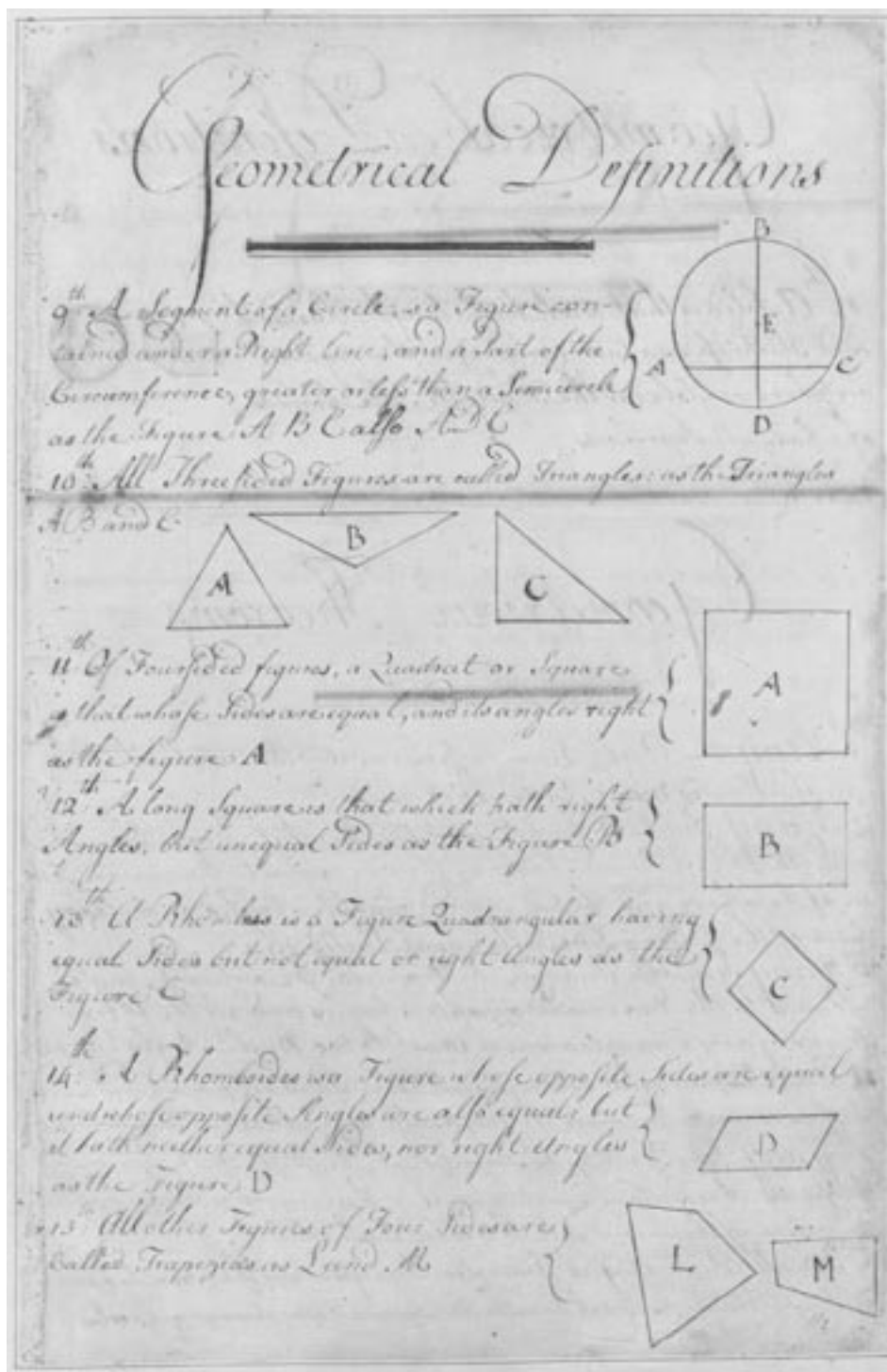
Surveying compass face drawn by George Washington in 1750.

Geometrical Definitions

George Washington wrote these "Geometrical Definitions" when he was your age. The exercises are included in his homework notebooks at the Library of Congress. You are studying the same math concepts as George Washington. Note the different terms such as rhomboides for a parallelogram.

"Geometrical Definitions" Transcription

9th. A Segment of a Circle is a Figure contained under a right line, and a Part of the Circumference, greater or less than a Semicircle as the Figure ABC, also ADC.

10th. All three sided figures are called Triangles: as the Triangles A, B, and C

11th. Of Four sided figures a quadrant or Square is that whose Sides are equal, and its angle right as the figure A.

12th. A long Square is that which hath right Angles but unequal Sides as the Figure B.

13th. A Rhombus is a Figure Quadrangular having equal sides but not equal or right angles as the Figure C.

14th. A Rhomboides is a Figure whose opposite Sides are equal and whose opposite Angles are also equal: but it hath neither equal sides, nor right Angles as the Figure D.

15th. All Other Figures of Four Sides are called Trapezoids as L and M.

Land Measurements for Surveyors

Why did George Washington and all the surveyors use the Gunters Chain to measure land?

THE REASON IS ONE SQUARE GUNTERS CHAIN EQUAL 1/10TH OF AN ACRE. TEN SQUARE GUNTERS CHAINS EQUAL 1 ACRE—THIS IS NOT A PERFECT BLOCK OR SQUARE BUT 10 SMALLER SQUARES.
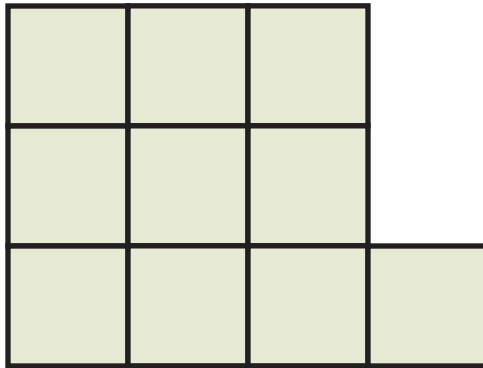
The Gunters Chain was the easiest method for measuring the vast wilderness frontier and converting the survey into acres.

LINEAR

- 1 LINK = 7.92 INCHES
- 25 LINKS = 1 POLE OR 16.5 FEET
- 100 LINKS = 1 CHAIN OR 66 FEET OR 4 POLES
- 10 CHAINS = 660 FEET OR 40 POLES
- 80 CHAINS = 1 MILE

SQUARE

- 1/10TH ACRE = 1 SQUARE GUNTERS CHAIN

- ACRE = 10 X (1 SQUARE GUNTERS CHAIN)

- ACRE = 10 X (1 GUNTERS CHAIN X 1 GUNTERS CHAIN)

- ACRE = 10 X (100 LINKS X 100 LINKS) = 100,000 SQ LINKS

- ACRE = 10 X (66 FEET X 66 FEET) = 43,560 SQ FEET

- 1 Sq Chain = 10,000 links $\dfrac{\text{Number of Links}}{10,000} = \text{Sq Chains}$

- 1 Acre = 100,000 links $\dfrac{\text{Number of Links}}{100,000} = \text{Acres}$

Math for Land Surveyors

AREA = BASE X HEIGHT

FORMULA FOR:
- SQUARES
- RECTANGLES
- PARALLELOGRAMS

EXAMPLE:

$\mathcal{A}$ — $\mathcal{B}$

215 links

$\mathcal{D}$ — 215 links — $\mathcal{C}$
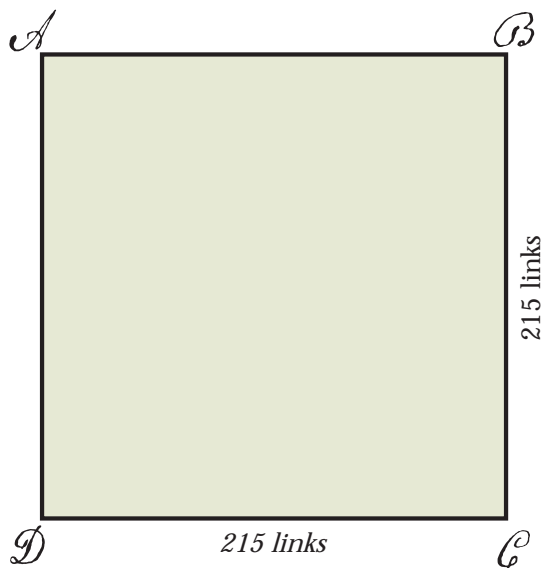
- AREA = BASE X HEIGHT
- AREA = DC X CB
- AREA = 215 x 215
- AREA = 46,225 Sq Links

- 10,000 Sq Links = 1 Sq Chain

- $\frac{46,225}{10,000}$ = 4.6225 Sq Chains = 4 Chains 6225 links

- 100,000 Sq Links = 1 Acre

- $\frac{46,225}{100,000}$ = .46225 Acres

Work Space

Math Lesson One

Find the area in links, chains, and acres of each square. Use the area to find the length of the sides in links, sq chains and sq links.

Area = Base X Height

1.

A _____ *B*

| |
| 1321 links |

D _____ *1321 links* _____ *C*
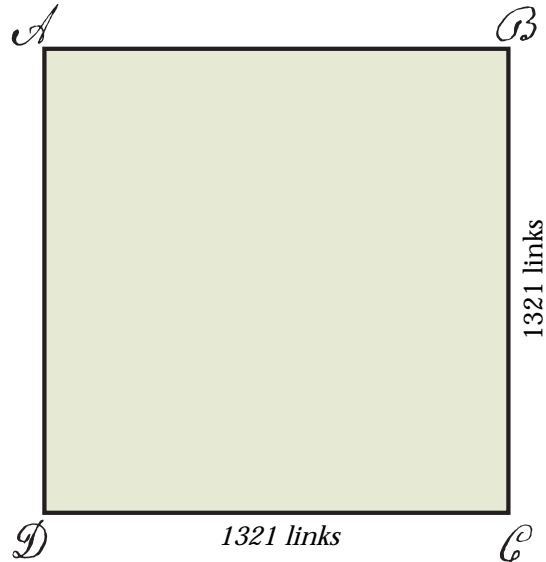
ABCD =   _____ **sq links**   **Work Space**

                     _____ **sq chains**

                     _____ **acres**

2. Square with sides of 632 links

                     _____ **sq links**

                     _____ **sq chains**

                     _____ **acres**

3. Square with sides of 758 links

                     _____ **sq links**

                     _____ **sq chains**

                     _____ **acres**

4. Square with sides of _____ links

                     _____ **sq links**

                     _____ **sq chains**

                14.61681 acres
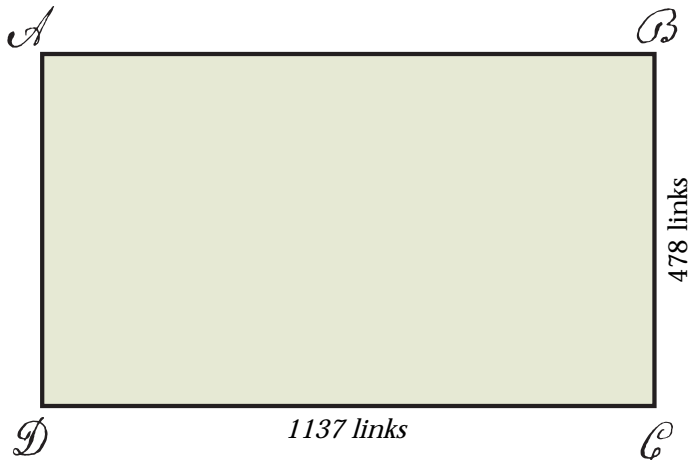
Math Lesson Two

Find the area in links, chains, and acres of each rectangle. Use the area to find links, sq chains, and acres.

AREA = BASE X HEIGHT

1.

A ──────────────────── B

478 links

D ── *1137 links* ── C

ABCD = _____ **sq links**
_____ **sq chains**
_____ **acres**

2. Rectangle with sides of 778 links and 284 links

_____ **sq links**
_____ **sq chains**
_____ **acres**

3. Rectangle with sides of 863 links and 475 links

_____ **sq links**
_____ **sq chains**
_____ **acres**

4. Rectangle with sides of 1657 links and 1389 links

_____ **sq links**
_____ **sq chains**
_____ **acres**

5. Rectangle with sides of 1877 links and _____ links

1,846,968 sq links
_____ **sq chains**
_____ **acres**

Work Space

Parallelograms
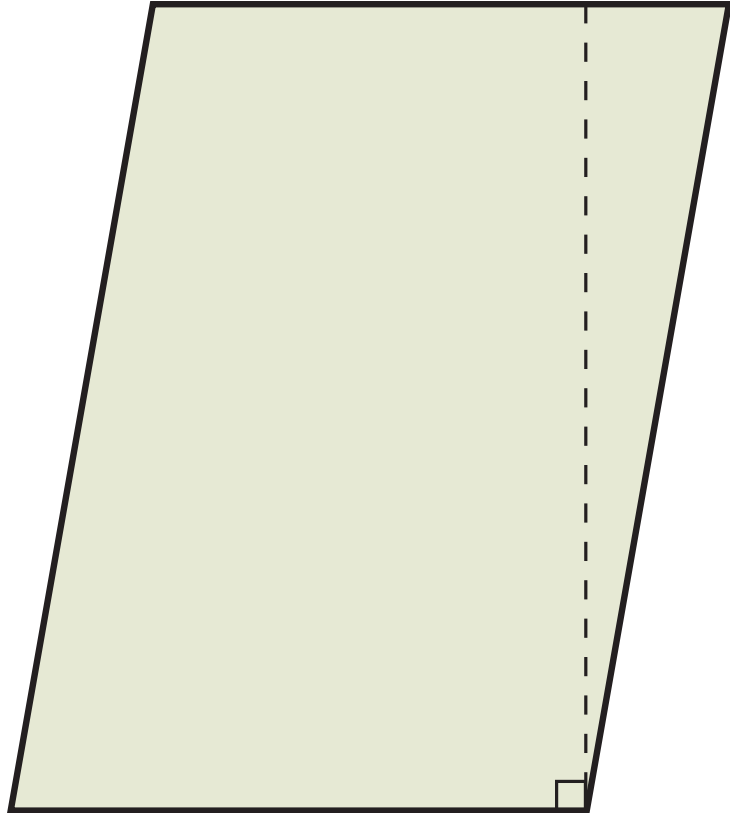
Parallelograms are four-sided polygons. Detach the following page. Fold the broken line on the paper and tear the triangle off the sheet. Fold the sheet along the right side solid line of the triangle. Place the triangle on the opposite side of the parallelogram.

What shape does this make?

THIS IS THE REASON PARALLELOGRAMS USE THE SAME FORMULA FOR AREA AS SQUARES AND RECTANGLES.

AREA = BASE X HEIGHT

fold & tear

fold
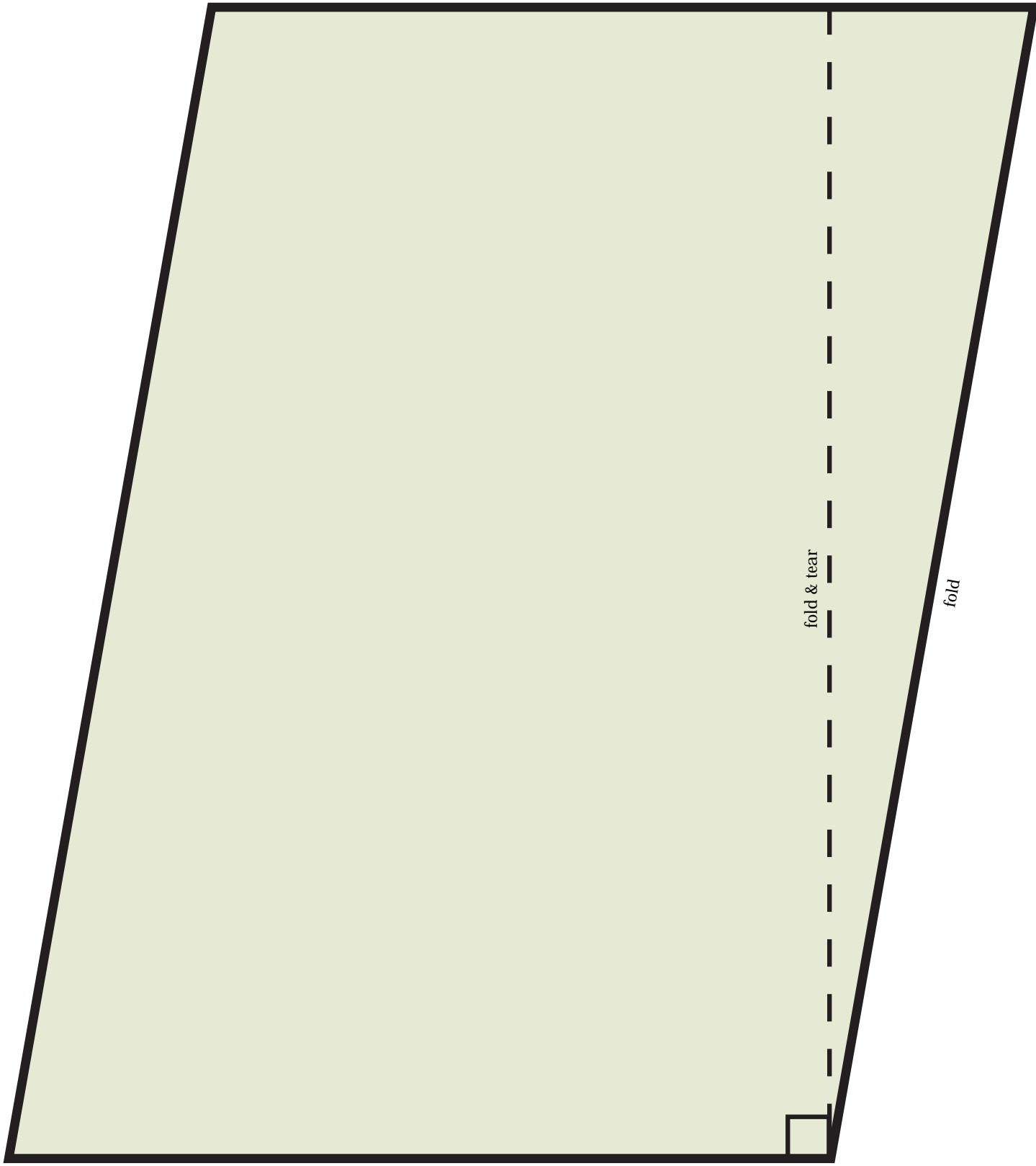
Math Lesson Three

Find the area in links, chains, and acres of each parallelogram. Use the area to find links, acres, and sq links.

AREA = BASE X HEIGHT

1.

A · · · · · · B
1629 links
D · · · · · · *C*
1408 links
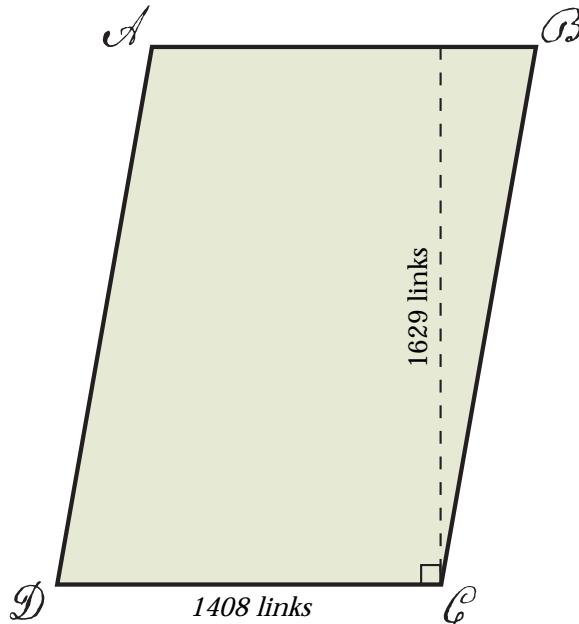
ABCD = _____ **sq links**
_____ **sq chains**
_____ **acres**

2.   Base = 2563 links   Height = 847 links

_____ **sq links**
_____ **sq chains**
_____ **acres**

3.   Base = 738 links   Height = 1761 links

_____ **sq links**
_____ **sq chains**
_____ **acres**

4.   Base = _____ links Height = 226 links

_____ **sq links**
12.2718 sq chains
_____ **acres**

Work Space

Triangles

Triangles are three sided polygons. As you look at the triangle below, draw a congruent triangle by connecting the two corners of the triangle to the dot (draw two straight lines).

•
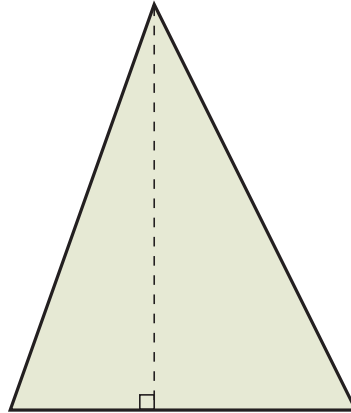
What shape does this make?
A PARALLELOGRAM
THE TRIANGLE IS 1/2 OF THE PARALLELOGRAM.

THIS IS THE REASON THE AREA OF THE TRIANGLE IS
1/2 THE AREA OF THE
PARALLELOGRAM

AREA OF A TRIANGLE = 1/2 BASE X HEIGHT

EXAMPLE:

- Area = 1/2 Base x Height
- Area = 1/2 327 x 534
- Area = 1/2 174618
- Area = 87309 Sq Links

- 10,000 Sq Links = 1 Sq Chain

- $\frac{87,309}{10,000}$ = 8.7309 Sq Chains = 8 Sq Chains = 7309 Links

- 100,000 Sq Links = 1 Acre

- $\frac{87,309}{100,000}$ = .87309 Acres

A

534 links

C 327 links *B*

Math Lesson Four

AREA OF A TRIANGLE = 1/2 BASE X HEIGHT

Find the area in links, chains, and acres of each triangle. Use the area to find the links, sq chains, and sq links.

1.

Triangle with apex *A*, base from *C* to *B*. Height = 498 links, base = 584 links.
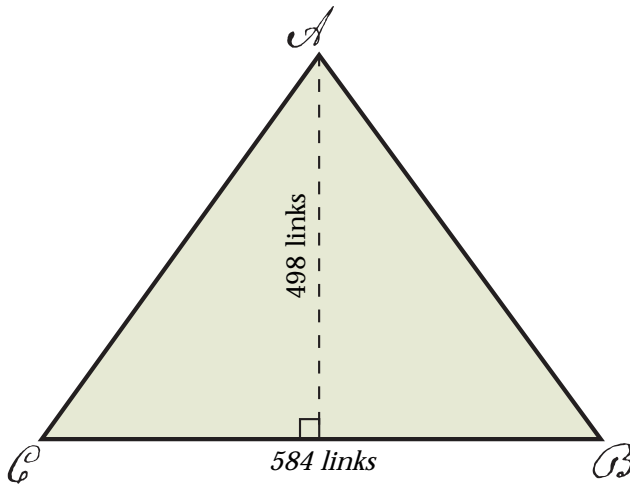
ABC =   _____ **sq links**
                _____ **sq chains**
                _____ **acres**

2. Base = 236 links Height = 168 links

                _____ **sq links**
                _____ **sq chains**
                _____ **acres**

3. Base = 147 links Height = 172 links

                _____ **sq links**
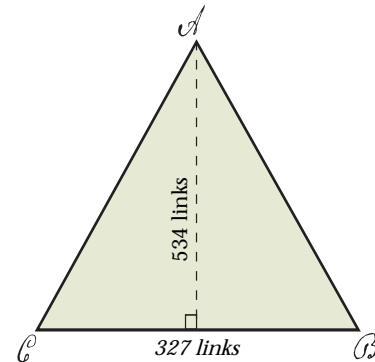   _____ **sq chains**
                _____ **acres**

4. Base = 233 links Height = _____ links

                _____ **sq links**
                _____ **sq chains**
             .21436 acres

Work Space

Science for Land Surveyors

Erosion is the wearing away of earth or rock. Since the earth was formed erosion has taken place. George Washington was aware of erosion in the farm fields and wanted to stop this washing of gullies in the fields by planting grass. The following excerpt is from a letter George Washington wrote to one of his farm managers (overseers) on January 27, 1793:

"I wish you may not find No. 4 and 5 at the River Plantation very unproductive fields; and very injurious to break, unless it is done with judgment. My intention was to keep them for common pasture; To have endeavoured to stop the gullies; and to have prevented the washed places from getting worse by covering them with Straw; and to have sown the Seeds of the common locust thereon, or something that would (in a few years, have cloathed it with a growth that would have proved a remedy for the present evil. That field is very apt to wash, at present it is very much gullied, and if uncommon attention is not paid to it in the working and in laying it down it will be unfit hereafter for grass even except in a few spots." (Fitzpatrick, John C., *The Writings of George Washington,* Washington, D.C.: United States George Washington Bicentennial Commission, 1939, Vol. 32, p. 319.)

Erosion changed the way the land features looked in George Washington's time. Think of how much the landscape today has changed since George Washington surveyed. Pictures of different agents of erosion on different types of landscapes are accessible on the Education page of the park's web site. George Washington Birthplace National Monument's web site is www.nps.gov/gewa..

Visit our web site at
www.nps.gov/gewa

Student Erosion Review

Define Erosion:

List four agents of erosion:

Give five examples of erosion and list their causing agents.

Explain the difference between chemical and physical weathering.

What is the key to all types of erosion?

Explain how you could tell the difference between materials that have been weathered for a long time versus those weathered for a short period.

How can humans cause erosion of the earth?

Are there any means of stopping erosion? Why or why not?

*Does erosion mean that when materials are weathered or changed that the removed matter has disappeared? Why or why not?

George Washington's Survey for John Lindsey, November 17, 1750

Transcription

A - **B** S 45□ W 160 poles = 40 chains = 4000 links

B - **C** N 45□ W 234 poles = 58.5 chains = 5850 links

C - **D** N 45□ E 144 poles = 36 chains = 3600 links

D - **A** S 48□ N 236 poles = 59 chains = 5900 links

Pursuant to a Warrant from the Proprietors's Office to me directed I have Survey'd for Mr. John Lindsey a certain tract of waste and ungranted land in Frederick County bounded as followeth viz.

Beginning at a walnut and Red Oak Morris's Patent and in the line of a late survey made for Isaac Pennington and extended along the said Pennington's Line S 45□ W 160 poles to a white Oak and double white hicy (hickory) near a limestone Rock thence N 45□ W 234 poles to a red Oak and locust Sapling in the — Barrens thence N 45□ E 92 poles to Captn. [ ] Corner 144 poles to two red oaks Morris's Cr. thence with his line S 48□ E 236 poles to the Beg: Contg

_____acres - Novr: 17th 1750.

   by Washington

   Henry Hendrick — CC
Stephen Sebastian —
John Lindsey – Marker
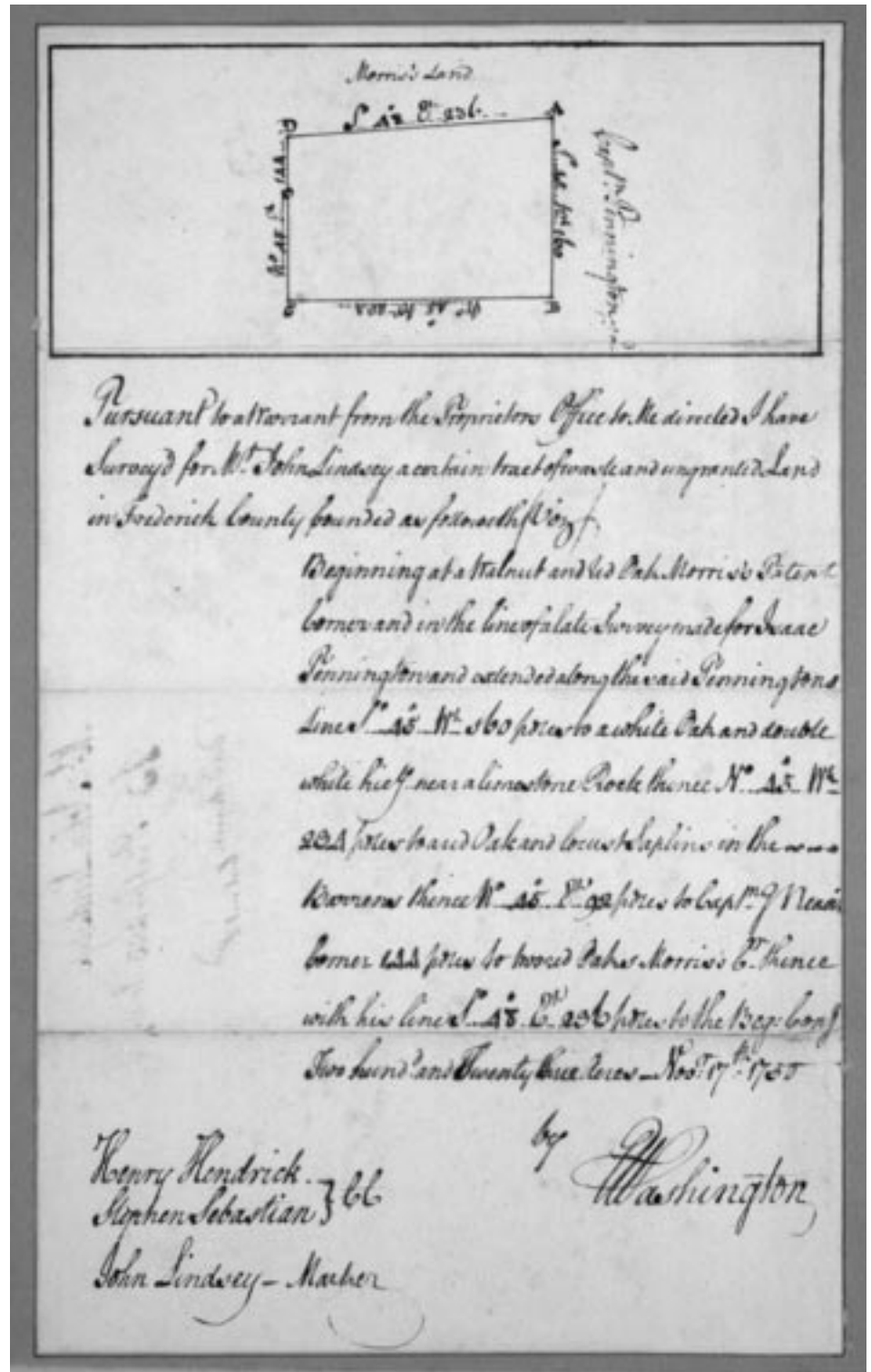
Follow-Up Activities

Follow-Up Activities are to be completed after your visit to the park.
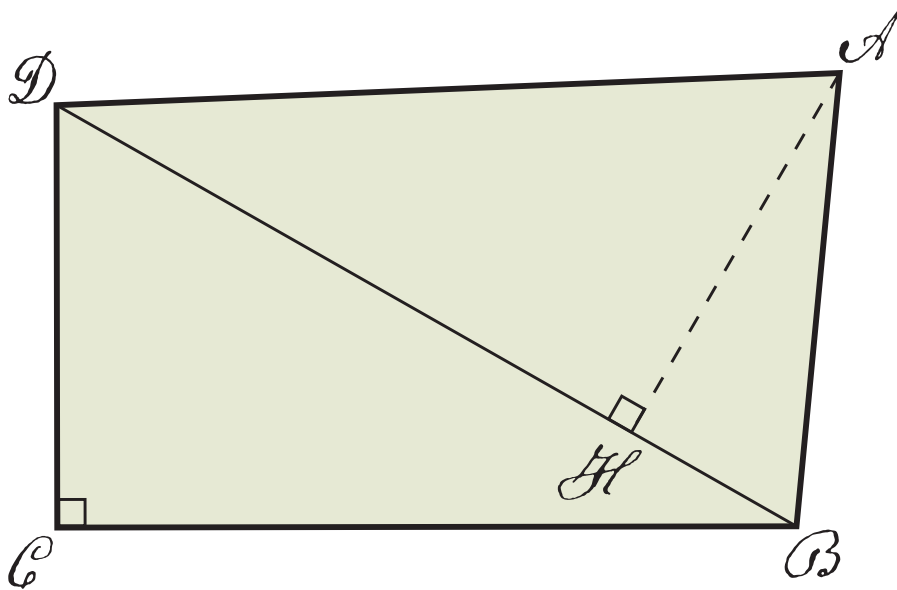
Math:

The survey for John Lindsey on the previous page was conducted by George Washington when he was eighteen years old. **Find the area for George Washington's survey by dividing it into two triangles and adding the area.**

DB = 6869 links   AH = 3436 links
CD = 3600 links   CB = 5850 links

Follow-Up Activities continued

Science:

Have the students complete the following assignments individually.

A. The students will demonstrate their knowledge of the erosion processes in their own community. Students will bring in a representation (photos, sketches, video, newspaper clipping, etc.) of erosion from their community and explain the **agent** of erosion, the **impact** of erosion (short term and long term), and propose a solution to slow down the erosion process.

B. Students will describe the physical characteristics of their favorite tree using the classification system they used at George Washington Birthplace National Monument (leaf, bark, flowers, fruit, seeds, habitat, and range). Students will describe where the tree is located and explain why the tree is their favorite (physical characteristics, sentimental or associative reasons). The class will then attempt to identify the tree from the student's description.

C. Students will identify the role of the National Park Service in a written report. The importance of protecting wildlife, the natural landscape (from seashores to wilderness areas), and historical sites for future generations should be the main theme. George Washington Birthplace National Monument could be used as an example of a historical site that contains important wildlife (eagles) and a delicate eco-system (Chesapeake Bay watershed).

Glossary

Acre: Unit of land measuring 220 yards square, used in the United States and England

Cadastral: Showing or recording boundary lines, land

Clearcut: Term to describe cutting of all timber on a tract of land

Gentry: The condition or rank of a gentleman, the upper or ruling class

Gunters Chain: A chain 66 feet long that is the unit of length for surveys

Indentured Servitude: A contract binding one person to work for another for a specified time in return for payment of travel expenses and living expenses

Landscape: The shape or features of an area of the earth's surface caused by nature or by man

Link: Unit of length that is part of a Gunters Chain measuring 7.92 inches long

Metes and Bounds: The points of reference for a survey such as the boundary lines and corners

Northern Neck of Virginia: The land that lies between the Potomac and Rappahannock Rivers that today includes Lancaster, Northumberland, Richmond, Westmoreland, and King George Counties

Pole: Unit of length measuring 16.5 feet

Surveying Compass: A device for identification of directions using a magnetic needle that turns freely on a pivot and points to the magnetic north. The compass has 360 degrees and is used in marking boundaries and lines for land surveys.

Surveyor: A person that measures an area of land, notes the lengths and directions of the bounding lines, and records the information on paper

Survey Warrant: A written document to guarantee a person ownership of a specified number of acres of land to be surveyed

Talus: A slope formed by rock debris at the base of a cliff

Transcendent: Going beyond the limits of ordinary experience or time

Traversed: A line surveyed across a plot of ground

"Surveying is the art of measuring land and it consists of three parts...

1st the going round and measuring a piece of woodland

2nd plotting the same, and

3rd to find the content thereof."

George Washington at 13 years of age.